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OBSERVATIONS *on the* VARIATION *of the* NEEDLE.*By Mr. THOMAS HARDING, M. R. I. A.*

THE variation of the Magnetic Needle is measured by an arch of the horizon, intercepted between the true and magnetic meridian. To account satisfactorily for such deviation, and still further for the variation of that deviation, at different times and places, has not yet fallen to the share of any philosopher, notwithstanding the several hypotheses framed for the purpose of explaining the phenomena.

Read May
7, 1791.

THE fact is, that bare hypotheses are seldom useful (often dangerous) to science. In the present case, I am persuaded that we shall never be able to arrive at a true theory of the variation of the needle, without the advantage of numerous observations made at sundry distant places, at the same, and also at different, times: It is therefore much to be wished that a correspondence were established among the learned, for this and all such useful purposes, and that experience were substituted for systems founded only on conjecture.

THE ingenious Mr. Churchman of Philadelphia merits respect for endeavouring to add something to the common stock of knowledge, but I doubt the truth of his system for the following reasons. The variation of the needle has been increasing here since the year 1657, and the measure of it this month, at Dublin, is 27 degrees 23 minutes westerly, and in the year 1794 we may expect it will be still greater; but by Mr. Churchman's Chart of the Northern Hemisphere, which is constructed for that year, the variation measures barely 19 degrees: At present it differs from the truth more than eight degrees, and if the following observations can be depended on, I may venture to affirm the difference that year will be much more considerable.

It is now nineteen years since I first paid a serious attention to this surprising phenomenon, the change of the variation of the Horizontal Needle, and my experience ever since has convinced me it is uniform at Dublin. This is the chief point, first to be determined, and the next, which naturally follows, is an enquiry whether it be so in every other place, or not: Here, I am confident, and hope to prove, it has varied, since the year 1657, at the rate of about 12 minutes 20 seconds annually. The query is, What is its ratio elsewhere? This can only be discovered by general observations, as I mentioned before; and until this be effected any idea of finding *the longitude by the variation* must be delusive.

OCTOBER

OCTOBER 1788 I published a small treatise on the calculation of Areas arithmetically, in which I mentioned the variation found in September, which was 26 degrees 50 minutes westerly, and gave a general rule for finding it at any time, as also a problem for restoring lost or defaced boundaries, by the variation, as follows, viz.

HAVING the notes of a survey recently taken (by the needle) to find what the bearing of any stationary line was any number of years past, since the year 1657.

R U L E.

MULTIPLY 12 minutes 20 seconds by the years elapsed, and add the product to the present bearing, the sum will be the bearing required, and *vice versa*.

I COME now to the proof of my assertion, viz. that the change of the horizontal needle is uniform at Dublin. We have sundry authentic records to shew that the variation was easterly prior to the year 1657, and that in 1657 there was no variation in these kingdoms. With respect to the former, Mr. Burrows, Mr. Gunter, and Mr. Gellibrand are sufficient evidence; the first, in 1580, observed it to be 11 degrees 15 minutes east of the meridian of Greenwich; the second, in 1622, six degrees easterly; and the last, in 1634, four degrees five minutes easterly. In the year 1657 the magnetic and true meridians coincided in Ireland according to the Down Survey, or in other words, there was no variation.

In

In 1745 Mr. Roger Kendrick writes it 18 degrees west.

In 1751 Mr. Gibson published it 19 degrees west.

In 1772 I found it, by several careful observations, 23 degrees 30 minutes west.

In 1786, May 26th, I also found it 26 degrees 21 minutes west.
And,

In 1790, September 27, - - 27 degrees 15 minutes west.

THESE were all published at the times they were observed.

THE data here given I presume are sufficient to prove the uniformity at Dublin.

IT should be noticed that Mr. Gibson published his account of the variation in 1751, and the year following, viz. in 1752, he affixed the same variation to a map now in the possession of William Deane, Esq. which is a proof that he was unacquainted with the annual change.

BEFORE I begin the general operation, I cannot avoid remarking, with a degree of astonishment, that there is *not one observation on the variation of the needle to be found in any of our city records from the year 1657 to the year 1745*, at which time *Roger Kendrick, then City Surveyor*, mentions that it was 18 degrees westerly, as appears by a map of part of the lands of Baldoyle in the Town Clerk's office at the Tholsel. This circumstance reflects no credit on the *Land Surveyors of Ireland*. They must have had little curiosity during that time, or have been totally excluded from any intercourse with learned societies abroad, every one of which
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has something to offer on the subject. Yet there is no doubt but it was observed by some person here in the year 1712 to be 11 degrees 15 minutes west, and *as Joseph Moland was then City Surveyor* I was in full expectation of getting some intelligence from him; but in that particular I was disappointed, as not one of his maps either of town or country, for the space of twenty years, makes the least mention of it.

GIBSON'S Surveying, page 308, gives the variation 11 degrees 15 minutes in the year 1722; but it must have been a mistake (probably an error of the press), for that year it was found to be 14 *degrees 13 minutes by Mr. Graham in London*; however, as I can neither employ foreign observations, nor any of a doubtful nature at home, in the following calculations, I must, for the present, content myself with requesting that any nobleman or gentleman who may be in possession of a map or record made between the year 1657 and 1745, expressing the variation, will be so kind as to send an account of it to the Secretary of the Royal Irish Academy as soon as convenient. Now, though I am confined to Mr. Kendrick's observation in 1745, because no other has been committed to writing, yet I am of opinion he had as little idea of any regular increase in the variation as any of his predecessors: I am persuaded it was the case, for we find another map of his in 1753, in the aforesaid office, denoting the variation 19 degrees; the same that Mr. Gibson published it in 1751. A second consideration convinces me of this, viz. that he always writes the variation in whole degrees, viz. either 18 or 19, (and that for a succession of years);
yet,

yet, however deficient either of them may be, I am obliged, through necessity, to take up their dates and proceed as follows :

GENERAL OPERATION.

1. FROM 1745 take 1657, the remainder is 88 years ; divide 18 degrees, reduced to minutes, viz. 1080 by 88, the quotient is 12 minutes 16 seconds.

2. FROM 1751 take 1657, the remainder is 94 years ; divide 19 degrees, reduced to minutes, viz. 1140 by 94, the quotient is 12 minues eight seconds nearly.

3. FROM 1772 take 1657, the remainder is 115 years ; divide the minutes in 23 degrees 30 minutes, viz. 1410 by 115, the quotient is 12 minutes 16 seconds nearly.

4. FROM 1786 take 1657, the remainder is 129 ; divide 26 degrees 21 minutes, reduced to minutes, viz. 1581 by 129, the quotient is 12 minutes 16 seconds nearly.

5. LASTLY, from 1790 take 1657, the remainder is 133 ; divide the minutes in 27 degrees 15 minutes, viz. 1635 by 133, the quotient is 12 minutes 18 seconds nearly.

THE intermediate dates being compared (except the two first, which can be accounted for) will exhibit the same numbers nearly. Any small difference, arising from a comparison of the intermediate dates, should be attributed to a want of attention to the
annual

annual change, which might make a difference of a year or two in the computation (as is the case with respect to Mr. Gibson). Without the strictest regard to the dates, as well as the precise quantity of the annual difference, short intervals of time to estimate by are very uncertain.—The intermediate dates, however, are next to be compared.

1. FROM 1751 take 1745, the remainder is six years ; and from 19 degrees take 18 degrees, the remainder, reduced to minutes and divided by six, quotes only 10 minutes. [In this instance, the interval being small, and the variation in all likelihood not very accurate, the quotient must be ambiguous, as before remarked ; but if what I have to say hereafter be admitted, the increase of the variation, even in this short interval, will come up to my expectation.]

2. FROM 1772 take 1751, the remainder is 21 years ; and from 23 degrees 30 minutes take 19 degrees, the remainder, reduced to minutes and divided by 21, quotes 12 minutes 51 seconds.—[By these two it is evident Mr. Gibson might have supposed the variation for several years the same, or, at least, imagined that two or three years would make no sensible alteration ; but one year, in this instance, makes a difference in the calculation of 35 seconds.]

3. FROM 1786 take 1772, the remainder is 14 years ; and from 26 degrees 21 minutes take 23 degrees 30 minutes, the remainder, reduced to minutes and divided by 14, quotes 12 minutes 13 seconds nearly.

4. LASTLY, from September 27th, 1790, take May 26th, 1786, there remain four years and four months; and from 27 degrees 15 minutes take 26 degrees 21 minutes, the remainder, divided as before, quotes 12 minutes 27 seconds. The mean deduced from these and several others (not here inserted for brevity's sake) is about 12 minutes 20 seconds. Hence I conclude that the uniform change is 12 minutes 20 seconds annually. If this be so, then the year, when there was no variation at Dublin, may be discovered, by saying as 12 minutes 20 seconds is to one year, so is 27 degrees 15 minutes (the variation found in 1790) to the number of years elapsed, thus

$$\begin{array}{ccccccc} & & \text{Yr.} & & & & \\ : 12' 20'' & : 1 & :: 27^{\circ} 15' & : 132\frac{1}{2} \text{ years.} \end{array}$$

From 1790

Take 132 $\frac{1}{2}$

Remains 1657 $\frac{1}{2}$, the precise time when there was no variation here.

NEXT let it be required to find what the variation was in the year 1751, when Mr. Gibson published an account of it.

From 1790

Take 1751

39 remains.

Multiply 12' 20" or 740 seconds by 39, the product is 28860 seconds, which reduced is eight degrees one minute. This taken from 27° 15', the remainder is 19° 14', one-fourth of a degree more than Mr. Gibson found it; from which it is evident
the

the variation in 1750, and not in 1751, was 19 degrees, and that he had no idea of its being more in 1751 or 1752 than in the year 1750, agreeable to a former remark. This mistake of Mr. Gibson accounts for the difference in the second example of the general operation, and the first and second of the intermediate dates. For instance, if it be allowed that in the year 1750 the variation was 19 degrees westerly, let the second example of the *general operation* be repeated thus: From 1750 take 1657, the remainder is 93; divide 19 degrees, reduced to minutes, viz. 1140 by 93, the quotient is 12 minutes 16 seconds, nearly, instead of 12 minutes 8 seconds, as is there stated. Again, in the first example of the intermediate dates, from 1750 take 1745, the remainder is five years, and from 19 degrees take 18, the remainder is one degree, equal to 60 minutes, which divided by 5 quotes 12 minutes. [Here again I cannot help remarking that even the deficiency in this instance may be the consequence of a want of precision in the interval of time as well as the quantity of the variation; five months would have made the ratio complete, and as it certainly was Mr. Kendrick's custom (as well as Mr. Gibson's) to write the same variation several years, no doubt he might have written the same in 1744. This will be worth trying by the ratio; that is, let it be required by the annual rate of 12 minutes 20 seconds to find when the variation was 18 degrees westerly: I shall postpone the operation till the intermediate dates are finished.] In the second example, say, from 1772 take 1750, the remainder is 22 years, and from 23 degrees 30 minutes take 19 degrees, the remainder is 4 degrees

30 minutes, which reduced to minutes and divided by 22, the quotient is 12 minutes 16 seconds.

Now I will try what the analogy respecting Mr. Kendrick's date will produce.

$$\begin{array}{ccccccc} & & & \text{Yr.} & & & \\ : & 12' & 20'' & : & 1 & : : & 18^{\circ} : 87\frac{1}{2} \end{array}$$

So that early in the year 1745 the variation must have been 18 degrees westerly

LASTLY, to prove, by the ratio, that the variation was 19 degrees in the year 1750,

$$\begin{array}{r} \text{From 1750} \\ \text{Take 1657} \\ \hline 93 \text{ remains.} \\ \hline \end{array}$$

Multiply 12 minutes 20 seconds or 740 by 93, the product is 68820 seconds, which reduced is $19\frac{1}{5}$ degrees : some time therefore in the year 1750, I conclude, the variation was 19 degrees westerly, and not in 1751 or 1752, as Mr. Gibson has noted it, and consequently it could not be so in 1753, *when Mr. Kendrick, the City Surveyor, sanctioned it with the authority of his name.* I speak thus, to excite every person concerned in maps of a public nature (in short either public or private) to care and attention. An omission of the measure of the variation of the needle, especially in extensive maps of any part of the country, is very reprehensible, because the boundaries may be so defaced that the oldest man living

living cannot point out a certain land-mark to trace them by; but while an ancient map exists, or the original Field Notes, if the magnetic meridian be drawn, or the variation expressed, every vestige of the land can be discovered, and its boundaries defined with the greatest ease. But this is only a secondary consideration. The first and most *material of all* is that of laying a foundation for a discovery of THE LONGITUDE BY SEA OR LAND; *for certainly, were the magnetic laws universally known, the LONGITUDE could be more readily ascertained by THEM, than by any other means.* At Dublin we are pretty certain the annual change is 12 minutes 20 seconds nearly, and when we know what it is in various other places to as great a certainty, we may expect to be “put in possession of such a system * as will account for or foretell what will be the future movements of this wonderful phenomenon, the magnetic influence,” all the world over.

THO^s. HARDING.

Trinity Place, Dublin,

April 23, 1791.

N. B. I SHALL offer my observations on the Libration of the Needle, or what is commonly called the Diurnal Variation, during eight months, to the consideration of the Royal Irish Academy, as soon as I can get time to adjust them.

Answers

* Churchman.

Answers to Mr. Churchman's Queries.

Variation at Dublin September 27th, 1790, - $27^{\circ} 15'$ West.

Latitude of Dublin - - - - $53^{\circ} 20'$ North.

Longitude of ditto, in time, 24 minutes 24 seconds west of
the meridian of Greenwich.